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Interim Scientific Report

ANNUAL TECHNICAL REPORT OF RESEARCH

ON

"STATISTICAL TECHNIQUES FOR SIGNAL PROCESSING"

Report Date: December 15, 1983

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This report describes the results obtained during the grant year 1 November 1982 to 31 October 1983. References are made to twelve publications produced or in preparation. The research supported was in the area of robust signal processing, particularly nonlinear filtering and smoothing. Results were obtained on quantization of filters and on multiple input robust matched filters. Considerable progress was made in the area of nonlinear filters and smoothers, where it appears that generalizations of median filters may be of considerable practical significance in applications such as speech and image processing. In addition, some further analytical results have been obtained on the statistical properties of median filter outputs for Markov models on signal-plus-noise. Results on output power spectral densities for white inputs have also been obtained for M-filters based on robust M-estimation.

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SUMMARY OF PROGRESS IN PREVIOUS YEAR (STARTING NOVEMBER 1, 1982) OF RESEARCH UNDER GRANT AFOSR 82-0022

The grant year covered by this report began on November 1, 1982; it
was the second year of continuing effort on the development of new
"Statistical Techniques for Signal Processing". The progress made in
the first year has been documented in the annual report dated December
1982. In addition, advances made over a five year period under a pre-
vious grant (AFOSR 77-3154) have been described in five previous annual
reports (dated December 1977, December 1978, December 1979, December 1980
and December 1981).

Here we summarize our activity in this latest complete year of
research effort. Some interesting and significant results have been
obtained and reported during this period; these are listed as references
[1] - [10] on page 4. Copies of references currently available are being
sent together with this report.

The paper [1] published early in the grant year establishes an
interesting and useful connection between results on robust hypothesis
testing and work on robust time-series interpolation and regression.
Published this year was the expository paper [2], which contains a ·
description of many of the important robust signal processing results
which have been developed by the principal investigator over the last
five years. Paper [3] was also published this year. It contains new
results on robust Wiener filtering for correlated signals and noise,
for which no corresponding results exist in robust hypothesis testing.
Paper [4] contains results on data quantization for narrowband signal
detection; it has recently been accepted for publication.

1

Our research objectives last year were to continue our work in robustness and quantization, and to begin a new thrust in the direction of nonlinear filtering and smoothing. We have, indeed, been able to make good progress in these areas.

A Ph.D. dissertation [5] was completed during this period, under the guidance and support of the principal investigator. It contains many useful new results on robust Wiener and matched filters for signal processing applications. In addition, it contains new results on optimum quantization schemes for Wiener and matched filters, which are of direct use in reducing the implementation complexity of such filters. Paper [6] contains results from this dissertation on the specific subject of multiple-input Wiener filters. Also arising from this dissertation is a paper that has been presented at a conference [7] and published in its proceedings. It contains results on quantization of filters that were obtained for [5]. In addition to these papers, a further paper on multiple-input robust matched filters has recently been submitted for publication [8].

In the area of nonlinear filters and smoothers our first results were presented and published in preliminary form this year [9]. This paper shows that generalizations of median filters may be of considerable practical significance in applications such as speech and image processing. In addition we have also obtained some further analytical results on the statistical properties of median filter outputs for Markov models on signal-plus-noise. For M-filters, which are based on robust M-estimates, we have derived results on output power spectral densities for white inputs [10]. We are continuing to make very good progress in this area, and some of our latest research results (obtained since November 1, 1983)
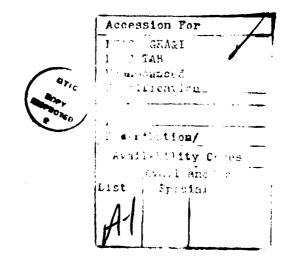
are discussed in a separate letter.

Finally, the principal investigator made good progress towards completing two major projects related to our research thrust. Invited paper [11] is scheduled for completion in this current grant period, as is the book [12] on nonparametric and robust signal detection.

PERSONNEL SUPPORTED

November 1, 1982 to
October 31, 1983:

Yong Hoon Lee, Granduate Student; Full Time.

Saleem A. Kassam, Associate Professor:
25% in November and December 1982;
100% in July and August 1983; and
30% September and October 1983.

3

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(List of Publications)

1. S. A. Kassam, "Robust Hypothesis Testing and Robust Time Series Interpolation and Regression," J. of Time Series Analysis, Vol. 3, No. 3, pp. 185-194, 1982.

2. S. A. Kassam and H. V. Poor, "Robust Signal Processing for Communication Systems," IEEE Communications Magazine, Vol. 21, No. 1, pp. 20-28, Jan. 1983.

*3. G. Moustakides and S. A. Kassam, "Robust Wiener Filters for Random Signals in Correlated Noise," IEEE Trans. Information Theory, Vol. IT-29, pp. 614-619, July 1983.

4. L. J. Cimini and S. A. Kassam, "Data Quantization for Narrowband Signal Detection" IEEE Trans. Aerospace Electronic Systems, Vol. AES-20, pp. - , 1984 (Accepted).

5. C. T. Chen, Robust and Quantized Linear Filtering for Multiple-Input Systems. Ph.D. Dissertation, Dept. of Systems Engineering, University of Pennsylvania, 1983.

6. C. T. Chen and S. A. Kassam, "Robust Wiener Filtering for Multiple-Inputs with Channel Distortion," IEEE Trans. Information Theory, Vol. IT-30, pp. - , 1984 (Accepted).

7. C. T. Chen and S. A. Kassam, "Optimum Quantization of FIR Wiener and Matched Filters," Proc. IEEE International Conf. on Communications, pp. - , June 1983 (Submitted for publication to IEEE Trans. on Comm.).

8. C. T. Chen and S. A. Kassam, "Robust Multiple-Input Matched Filters," IEEE Trans. Information Theory, (Submitted).

9. Y. H. Lee and S. A. Kassam, "Some Generalizations of Median Filters," Proc. IEEE International Conf. on Acoustics, Speech and Signal Processing, pp. 411-414, April 1983.

*10. Y. H. Lee and S. A. Kassam, "Some Statistical Properties of Generalized Median Filters," Proc. 21st Annual Allerton Conf. on Commun., Control & Computing, pp. - , Oct. 1983.

11. S. A. Kassam and H. V. Poor, "Robust Techniques in Signal Processing: A Survey," Proceedings IEEE (Invited Paper, in preparation).

12. S. A. Kassam, Modern Signal Detection Theory and Applications (to be completed June 1984).

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*Copies enclosed. Copies of the other available publications have previously been sent to AFOSR.